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ScienceDirect

Procedia - Social and Behavioral Sciences 146 (2014) 169 – 174

Procedia
Social and Behavioral Sciences

Third Annual International Conference «Early Childhood Care and Education»

The usage of eye-tracking technologies in rock-climbing

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Abstract

The research describes the possibility of applying eye-tracking technologies in sport training. The subject of current study was to determine and describe the visual strategies in prospecting rock-climbing routes by young athletes. Twenty three young rock-climbers participated in the experiment in indoor climbing gym. Via eye-tracking system authors investigate that the most effective visual strategy for the route preview in climbing is a strategy named «sequence of blocks» cause it's most connected with tactical component of training and anticipation phenomenon in sport.

Keywords: eye-tracking; gaze-tracking; visual search strategies; sport psychology; psychology of rock-climbing, young athetes

1. Introduction

Nowadays eye-tracking technologies become an inherent part of scientific researches [1]. Via eye-tracking systems scientists can detect eye movements and analyze human cognitive processing of visual information for interactive and diagnostic applications [2]. There is no doubt that performance in sport is linked to cognitive and perceptual skills as well as motor and physical abilities. Effects of cognitive training in sport fields (mental training, visualization etc.) are often discussed in sport psychology [3]. The possibilities of eye-movement registration have been described in researches of such sports, as: archery, football, basketball, hockey, golf, tennis and etc [4], [5], [6], [7], [8], [9]. Most researches deal with the following general gaze patterns: focus of attention and «zones of interest» (and ignored visual cues), scan path, number of saccades and fixations and its duration etc. Authors highlight the importance of applying eye-tracking technologies for diagnostic purposes in professional sport fields. The subject of current study was to determine and describe the visual strategies in

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doi:10.1016/j.sbspro.2014.08.075

prospecting rock-climbing routes by young athletes.
The importance of rock-climbing routes prospecting is frequently mentioned by rock-climbing coaches and elite climbers: Goddard D. and Neumann U. [10], Horst E.J. [11], Burbach M. [12], Sanchez X. et al. [13]. First, it deals with special conditions of rock-climbing competitions. More formal conditions of difficulty competitions in rock-climbing call for the competitors to wait for their turn to climb in an isolation zone. This zone also prevents the climber from seeing the routes, or even from coming in contact with anyone who has [12].
Thus, the highly developed ability to look through the route and analyze the crux parts of climbing routes (in order to plan alternative movements of hands or feet; to find some place to rest and to use chalk) is an inherent part of sport training.
In rock-climbing Nieuwenhuys A. and colleagues [14] investigated an anxiety-induced changes in movement and gaze behaviour of novices athletes (N=12) on a climbing gym. Two identical traverses were situated at high (4,25 meters) and low levels (0,44 meters) on a climbing wall to manipulate anxiety. In line with earlier studies, climbing times and movement times increased under anxiety. These changes were accompanied by similar changes in total and average fixation duration and the number of fixations, which were primarily aimed at the holds used for climbing. Combined with these findings, a decrease in search rate provided evidence for a decrease in processing efficiency as anxiety increased. These results approve the fact, that rock-climbing route preview and moving sequence planning are important in rock-climbing trainings and preparation for sport competitions. According to this, we hypothesized, that peculiarities of route preview (especially, eye-tracking of rock-climbing routes) depend on difficulty of routes.

2. Methods

2.1. Participants

Twenty three elite young rock-climbers, members of Moscow rock-climbing team (14 males, 9 females; Mean age = 16.09 years, SD=3.95) participated in the experiment. All subjects reported that they had normal visual acuity.

2.2. Apparatus

Participants' eye movement data were recorded using mobile device «Eye-tracking Glasses» of «SensoMotoric Instruments» (ETG SMI). ETG are non-invasive and robust system, which is equipped with a HD scene camera (resolution 1280*960 p). ETG provide reliable binocular eye-tracking data in both real-time and recorded data observations [2]. The eye movement registration system was calibrated using 3 nonlinear points. An eye calibration was performed for each participant to verify point-of-gaze before the trials and regular calibration controls were conducted during testing.
Before being tested, participants were familiarized with the experimental procedures.

2.3. Procedure

Nonetheless, most of published works that devoted to eye-tracking researches in sport has involved the use of laboratory-based simulations. We conduct our experiment in natural settings – during the athletes training on rock-climbing gym. Participants were invited to indoor climbing gym ("Big Wall", Moscow) to climb the two routes of intermediate and advanced level. Athletes should complete the routes on-sight in leading style.

1) The intermediate level route (6a+/6b). The first route consisted of 14 handholds and footholds and 4 quickdraws.

2) The advanced level route (7a+/7b). The second route consisted of 13 hand- and footholds and 4 quickdraws. The height of the both climbing routes was 5 meters. The routes were identifiable by color.

The grading system of French Rating Scale of Difficulty, which is common for mainland Europe, was used in this study [13]. The level of both climbing routes was chosen with the help of coach of young climbers' team (Bagova I.V.) according to the mean level of participants' performance.

For each trial, athletes were instructed to take up their position in front of the climbing wall and put on eye-tracking glasses for the route preview. They should follow the instruction: «…you should look through the route in front of you as you always do it on training or sport competitions» [15]. All rock-climbers had an appropriate warm-up before participating in the experiment.

Health and safety measures of the indoor climbing gym where the study was carry out were followed. Climbers were allowed to wear their own rock-climbing equipment (harness, shoes, chalk bag etc.). Additionally, the process of climbing was recorded on video.

2.4. Results

2.4.1. Analysis of fixations & route prospecting time

The intermediate route was completed by 100% of rock-climbers. Advanced route was completed by 52% of athletes, a half of the route completed by 35% of athletes, 13% of athletes fall down at the beginning of the route. The following eye-tracking parameters were analyzed: number of fixations, time of route prospecting, mean velocity of route preview (Table 1).

Table 1. Eye-tracking data of route prospecting

	Number of fixations		Time of route processing (s)	
Initials	Intermediate route	Advanced route	Intermediate route	Advanced route
S.A.	50	56	26	22
A.O.	72	51	38	22
M.A.	24	59	12	21
K.N.	96	116	38	34
Sh.D.	145	144	58	48
M.P.	9	33	6	10
N.M.	34	27	17	13
P.A.	24	45	12	15
S.V.	9	91	4	47
B.M.	63	37	21	13
K.S.	33	28	10	23
U.Yu.	114	114	46	40
K.E.	9	31	4	13
Ch.Ya.	13	63	13	22
S.D.	53	87	16	35
R.F.	8	59	33	18
A.M.	49	73	12	26
L.V.	76	81	20	25

G.M.	103	24	37	10
K.P.	20	51	7	17
B.D.	10	48	5	14
K.M.	3	81	11	36
D.E.	85	77	23	37

The data of correlation analysis indicated a significant positive correlations between number of fixations and the duration of route preview both for intermediate and advanced route (r(intermediate)=0,781, p<0,001; r(advanced)=0,885, p<0,001). We found out, that 56% of rock-climbers spent more time for advanced route preview than intermediate one. The mean number of fixations on one handhold has significantly risen (u=168, p<0,05).

2.4.2. Visual search strategies

Via analysis of eye-tracking video data we determine different types of visual strategies in prospecting climbing routes by athletes: «ascending strategy», «fragmentary strategy», «zigzagging strategy» and «sequence of blocks» (Table 2).

«Ascending strategy»: an athlete looks from below to upwards and finishes preview on the top hold (or quickdraw). This strategy is common for 21,7% of rock-climbers for intermediate route and it is not used for advanced route by them.

«Fragmentary strategy» - athlete looks through parts of a route and ignores a lot of holds & quickdraws. This strategy is common for 13% of climbers for intermediate route preview and for 8,7% of athletes for advanced route prospecting.

«Zigzagging strategy» [1]. The special characteristics of this strategy are: viewing the climbing route on a «zigzag», absence of long fixations on handholds or quickdraws, absence of block analyzing.

Zigzagging strategy is common for 13% of climbers for intermediate route preview and 4,3% of athletes for advanced route preview. It's interesting, that «zigzagging strategy» is common for athletes who have the high level of sport performance. We consider that «ascending» and «zigzagging» strategies are mostly connected with knowing the route at first glance (without deep analyzing), thus «ascending» and «zigzagging» strategies and less connected with tactical component in sport.

«Sequence of blocks»: the rock-climber gradually looks through a route by block of 2-4 handholds or footholds from a beginning up to the end, paying attention to crux moments of climbing route. Probably, using this strategy, athletes they visualize alternative ways of moving their hands or legs. It is also connected with anticipation phenomenon in sport: «for example, some climbers prefer to climb a route mentally using their hands while they still staying on the ground in front of it» [16]. This is the most widespread strategy among rock-climbers. It's also worthy to mention, that the frequency of its usage increases dependently on the route difficulty (52,2% for intermediate route and 87% for advanced route). We consider that, applying of this strategy is the most effective while preparing for the route, because an athlete analyses the route thoroughly and gradually (for example, crux moments, «places to have a rest and using chalk etc.).

Table 2. Percentage of usage different types of visual strategies

	Percentage	
Visual strategy	Intermediate route	Advanced route
Ascending	21,7	0
Fragmentary	13	8,7
Zigzagging	13	4,3
Sequence of blocks	52,2	87

Fig. 1. Examples of pre-ascent route processing by young rock-climbers

3. Discussion

Therefore, the hypothesis of research that particular qualities of eye-tracking depend on the level of difficulty of a rock-climbing route has been confirmed. While previewing a more difficult rock-climbing route, athletes spend more time and use more thorough strategies. Also the task, which was given to rock-climbers to analyze the routes before climbing, could have an educational impact on them. According to rock-climbing team's coach Bagova I.V., the similar tasks, connected with preliminary analysis of routes has already been used in sport trainings (for example, the sportsmen were to look through and remember a climbing route, then they were to draw it on a sheet of paper without looking at it). As for the system of eye-movements registration, it provided the opportunity to estimate such qualities of an athlete as attention and tactical thinking. Thus, these findings indicated that applying eye-tracking technologies can result in enhanced performance among young athletes.

The potential prospect of further research of applying eye-tracking systems in rock-climbing can be comparison of the results we have got in this research with the results of novice rock-climbers. We suppose that high professional level and rich experience provide frequent using of sequential previewing strategy (i.e. deep analysis of some parts of a route) and realizing the importance of "mental climbing" before climbing itself.

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